Dispersion Modelling Modification Task Group Recommendation Report for the Alberta Air Quality Guidelines

By the Model Modification Task Group
For Alberta Environmental Protection
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1.0 Introduction

1.1 Background

On January 30th, 1998, Alberta Environmental Protection (AEP) held a one-day workshop to discuss the latest draft of the Air Quality Model Guidelines (AQMG) that was issued in December 1997. This workshop was designed so that AEP could receive feedback on the content of the guidelines from stakeholders. The feedback that was received from the workshop was outlined in the subsequent "Report on the Proceedings of the Workshop on AEP's Draft AQMG" by CHEMInfo Services Inc. The report outlined major points that were brought forward by the participants. Three of the issues that needed to be resolved outside of the workshop were:

1. AEP should seriously consider the adoption of the ISC3 and then integrate the 0.55 factor into the model's code and then distribute the model to the various users in Alberta.
2. AEP should set up a task group to further analyse the issue of adopting the ISC3 and integrating the 0.55 factor into the model's code as well as how AEP should continually revise and redistribute the ISC model.
3. If the ISC3 model with the integrated 0.55 factor is adopted, then AEP should keep the model constant for a specific time period (e.g. 4 years) after which AEP should review the updates to the model provided by the EPA in order to make the appropriate changes and redistribute the model to users in Alberta.

1.2 Objectives

As a result of the workshop, a "Model Modification Task Group" comprised of a voluntary group of consultants, industry, and AEP, was set up to research and address points 3 through 5 of the workshop report. The task group has held a series of meetings to discuss the "0.55 correction factor" and investigate alternative options.

After investigating viable model options to implement in the guidelines, the group has come up with a set of recommendations to AEP. AEP will consider these recommendations prior to issuing the final draft of the guidelines. This document is a direct result from the meetings and the work that has arisen from them. Discussions at the meetings recognised that grandfathering and the implications on stack design could be affected by the selected recommendations from this report. Grandfathering is not directly addressed in this report; however, AEP is committed to addressing this issue in conjunction with the release of the final guidelines.

This report describes the background science behind the "0.55 correction factor", investigates its potential use, and identifies other modelling options.

Modelling that was performed in support of particular model options is also presented. The conclusions and recommendations of the Task Group are at the end of this report.

At the outset, it was deemed important to achieve unanimity amongst the group participants. However, as the workgroup progressed, group consensus was not attained. Therefore, the results presented here reflect the different viewpoints of the group.

2.0 Modelling Background

2.1 Introduction

This portion of this report discusses the background science behind the different options that have been investigated to improve plume dispersion estimates for regulatory purposes in Alberta. Specifically, an investigation into the United States Environmental Protection Agency (US EPA) Industrial Source Complex version 3 (ISC3) model and its plume dispersion parameters are discussed. A brief description of the ISC3 model followed by a comparison of two alternative model options is given. The first option is an adjustment to the model computer language code to reflect lateral dispersion as it was originally modelled (a.k.a. the "0.55 correction factor"). The second option is the use of the "highest n^{th} high" concentration predicted by the ISC3 model.

The "Modelling Background" and "Comparison of Results" section is geared towards a reader who has a technical background related to the environment. This section does not contain detailed information regarding plume dispersion and/or modelling. It is left up to the reader to access any information of further interest.

2.2 Model Description

ISC3 is a straight-line steady-state Gaussian dispersion model that is used to estimate concentrations of pollutants on terrain below or above plume height. ISC3 utilises hourly meteorological data as input to define conditions to predict concentrations at various time periods. It also allows for modelling of multiple point, area, volume, and open pit sources, stack-tip downwash, building downwash, as well as simple and complex terrain.

The ISC3 model has more options than the US EPA's SCREEN3 or Alberta's SEEC (Search for Extreme Ensemble Concentration) model. The SEEC model has been used in regulatory assessments in Alberta since 1988. SEEC is used to estimate worst case concentrations and allows for multiple sources and

building downwash but does not incorporate the other features that ISC3 includes. SCREEN3 estimates worst case concentrations, but only for a single source. It also includes many of the algorithms utilised by ISC3.

All three models use Gaussian dispersion, however, ISC3 and SCREEN3 use different dispersion parameter estimations than the SEEC model. This results in higher ground level concentration estimates from ISC3 and SCREEN3. Each of these models has been used for regulatory purposes in Alberta. However, in order to attain consistency in regulatory modelling results, the dispersion parameters must be reviewed and only one set of parameters must be chosen.

2.3 Dispersion Parameters

Part of the technique of estimating concentrations in the models assumes that both horizontal and vertical concentration distributions of pollutants within a plume are Gaussian. (Turner 1994) The horizontal (sigma-y) and vertical (sigma-z) standard deviation of emission distribution, known as the Pasquill-Gifford (P-G) dispersion parameters, were derived from observations to describe this type of dispersion. In the Gaussian equation the P-G dispersion parameters are numerical values, and are functions of atmospheric stability and downwind distance from the source. (Beychok 1994)

The horizontal P-G parameters were originally estimated over flat simple terrain at an averaging time of "a few minutes". (Pasquill 1961) Many modellers have interpreted "a few minutes" differently over the years (Beychok 1994), to range from three minutes to one hour. Pasquill later clarified that the averaging time over which the measurements were taken was three minutes (Pasquill 1976). He also subsequently proposed a re-examination of his coefficients and has suggested that they be revised. (Pasquill 1976) The US EPA decided to incorporate a one-hour averaging time to the P-G parameters in the ISC3 model, despite Pasquill's statements. Assuming a 1-hour averaging time is equivalent to assuming that the winds are steady for the entire hour, or have the same mean direction as the three-minute wind. Explained another way, it infers that the wind is consistent for twenty 3-min periods in one hour.

The result of applying the P-G parameters to a one-hour averaging time is a prediction of ground level concentrations that are conservative, (i.e. less dispersion predicted over the hourly time period). Historically in Alberta 3-min dispersion parameters have been used. Therefore, it is suggested that the EPA models could be adjusted to correct for the averaging time by changing the dispersion parameters.

In SCREEN3, the correction can be applied to the predicted concentrations for simple flat terrain. However, a multiple source or complex terrain situation is different. The correction can not be applied outside the model computer code.

The ISC3 model incorporates building downwash and complex terrain algorithms, which would be incorrectly affected by the adjustment if it were applied after concentration estimates were made. Therefore, the ISC3 model computer code would have to be adjusted so that the parameters are applied to a 3-min averaging time under the proper "setting" of a source. These estimates could then be compared with ambient guidelines. The following section outlines a potential methodology to implement this change in the ISC3 model.

2.4 Lateral Dispersion Adjustments

The general methodology to correct for the concentration estimates due to the difference in averaging times is outlined by equation (1), (Beychok 1994, Angle & Sakiyama 1991) It has been called the "peak-to-mean" relationship.

$$C_x/C_p = (t_p/t_x)^n \qquad (1)$$

Where t_p and t_x are any two averaging times, and C_p and C_x are the corresponding estimated concentrations and "n" is a power. These values will depend on numerous variables. (Beychok 1994)

The value of "n" is generally accepted to be a value of 0.2 for a plume centreline in rural conditions, but it can be slightly less in an urban setting. "n" is also a function of crosswind position in the plume and the time ratio. Studies show that it can range anywhere from 0.2 to 0.75. (Beychok 1994, Angle & Sakiyama 1991)

For concentration predictions on rural and flat terrain, a correction of

$$(3/60)^{0.2} = 0.55$$

can be applied to the ISC3 model to convert from 3-minutes to a 1-hour averaging time.

Although this adjustment is technically a correction to *concentration estimations*, it can also be applied to the *Gaussian equation*. A straightforward correction can be carried through the lateral dispersion parameter in the Gaussian equation. For a single source, the maximum concentration prediction will always occur at the plume centreline. The net result of the adjustment will be a predicted one-hour concentration that is reduced by 45% of the original estimation. Spatial concentrations in the vicinity of the maximum will also be predicted lower than

the ISC3 model. The reduction will depend on the relative position of a receptor to the plume centreline. See Appendix C for an explanation.

In a multiple source scenario, the maximum may not necessarily be reduced by 45%, as the maximum may occur away from any one of the plume's centrelines.

2.5 The "Highest nth High"(HnH)

Another way in which modelling results can be interpreted, which is accepted and used by the US EPA, is to base regulatory requirements on the "highest nth high" concentration, where n represents the number of predicted concentrations lower than the highest predicted level.

The ISC3 model predicts a series of concentrations for a given averaging time (e.g. 1-hour) over a given period (e.g. 1-year). For a group of receptors downwind of a source, the greatest predicted concentration for the series of averaging times is known as the "highest" or "maximum" concentration. The "second high" concentration can be defined as the second greatest predicted concentration that occurred at the given receptor during the period. The "highest second high"(HSH) is the maximum of all of the "second high" predicted concentrations for each receptor. The following illustrates the definition with a hypothetical example:

Given a typical point source and two receptors, A & B, both east of the source, the ISC3 model was run with 3hours of meteorological data. One-hour averages were predicted. Table 1 shows the results.

Table 1: Predicted Concentrations

Location	Time		
	Hour 1	Hour 2	Hour 3
Receptor A	230	500	200
Receptor B	220	490	250

Conclusions:

- 500 is the "maximum" or "highest" overall predicted concentration
- 490 is the "second highest" overall concentration
- 230 and 250 are the "second high" concentrations for receptors A & B respectively
- 250 is the "highest second high" concentration

Note that the "second high" concentration differs from the "second highest" concentration. The "second high" is point specific, whereas the "second highest"

is simply the second greatest concentration regardless of position or meteorology.

The HSH only exists due to a different meteorological hour. Models such as SCREEN3 are designed to simulate the worst case conditions and therefore the HSH can not be predicted. Utilising HSH in a model simulation is only possible if an actual meteorological data set is used. Without a sequential meteorological data file, the HSH can not be determined. In order to compensate for this shortcoming, a set of regional 'screening' meteorological data sets, could be generated. These data sets could aid users to migrate to ISC3 from SCREEN3, under circumstances where it is necessary.

The HnH is the equivalent of predicting the highest concentration regardless of location for each hour of the year (meteorological data set), and the highest second high would be the second highest hourly concentration predicted from the meteorological data set. This process can be repeated for the High Third High, and so on, until the desired level is reached. For example, the 99.91% concentration in a given year, is the highest 8^{th} high concentration. The ISC3 model can directly output data up to and including the 6^{th} High.

The next section shows a series of model results that compare model simulations of the regular ISC3 model (with different HnH levels) to the "0.55 factor" model results.

3.0 Comparison of Model Predictions

3.1 Introduction

The difference between the model predictions using the different dispersion parameters is important to establish. Once this is established, the implications of a model adjustment can be determined. Model simulations were completed for a series of point sources using the ISC3 default options for the highest and highest nth high (HnH) concentrations. The same set of sources and meteorological conditions were used to predict the highest concentrations with the peak-to-mean adjusted model.

3.2 Model Inputs

A variety of source types were selected as input into the models. Five point sources, one area, and one volume source were individually modelled to ensure that a majority of the aspects of the models were incorporated. Two multiple source scenarios were run to determine if significant changes occurred from

single to multi-source predictions. Table 3-1A,B, C, and D show the source characteristics for the modelled sources.

Table 3-1A Point Source Modelling Input Parameters

Source	Pollutant	Emission Rate (g/s)	Height of Stack (m)	Temperature (K)	Stack Diameter (m)	Exit Velocity (m/s)
Flare 1	SO_2	115	52.1	1273	0.6	20
Flare 2	SO_2	987	43.7	1273	4.2	20
Flare 3	SO_2	3	30.4	1273	0.117	20
Refinery Boiler	SO_2	57.5	76.2	450	2.7	11
Compressor Engine	NO_x	4.2	12.5	769	0.3	35.5

Table 3-1B Area[1] Source Modelling Input Parameters

Source	Pollutant	Area Emission Rate ($g\ s^{-1}\ m^{-2}$)	Release Height Above Ground (m)	Length of X side of Area in E-W direction (m)	Length of Y side of Area in N-S direction (m)
Parking Lot	NO_x	0.00000264	1	150	240

[1](Oriented in a North direction)

Table 3-1C Volume Source Modelling Input Parameters

Source	Pollutant	Volume Emission Rate ($g\ s^{-1}$)	Release Height Above Ground (m)	Initial Lateral Dimension of Volume (m)	Initial Vertical Dimension of Volume (m)
Storage Tank	Xlyene	1.74 E-03	14.6	6.37	6.79

Table 3-1D Cumulative Scenarios #1 and #2 Input Parameters

Scenario Name	Source	Pollutant	Emission Rate (g/s)	Height of Stack (m)	Temperature (K)	Stack Diameter (m)	Exit Velocity (m/s)
Cumulative 1	Flare 1	SO_2	115	52.1	1273	0.6	20
	Refinery Boiler	SO_2	57.5	76.2	450	2.7	11
Cumulative 2	Flare	SO_2	94	100	1273	0.3	20
	FGD Stack	SO_2	219	137	332	7	7
	Incinerator Stack	SO_2	255	107	736	1.8	24
	Coke Fired Boiler Stack	SO_2	105	107	517	5.8	29

Because predictions of HnH rely on meteorological data, four separate years of meteorological data from two locations in Alberta (Lloydminster Airport and Fort Saskatchewan FSRIA station) were selected for the comparison. The data sets included inputs of wind speed, wind direction, dry bulb temperature, Pasquill-Gifford stability class, and the convective mixing layer height.

For single-source model simulations, each source was placed at the origin, and all terrain in the vicinity was assumed to be flat. A set of discrete Cartesian co-ordinates was created around each source.

3.3 Model Results

Table 3-2A, B, C, and D show the predicted 1-hour concentrations for each scenario and meteorological year. The highest to highest sixth high values are presented. As expected, the peak-to-mean adjusted predictions are very close to 55% of the ISC3 model predictions. The values are slightly larger than expected due to the use of a discrete co-ordinate system with maximums occurring marginally off centre of the plume.

Table 3-2A Maximum Predicted Hourly Average Ground-Level Concentrations - Lloydminster Meteorological Data (1987)

Source	ISCST3 Predicted	0.55 σ_y Predicted	High-2nd-High	High-3rd-High	High-4th-High	High-5th-High	High-6th-High
	Maximum ($\mu g\ m^{-3}$)	Maximum ($\mu g\ m^{-3}$)	Prediction ($\mu g\ m^{-3}$)	Prediction ($\mu g\ m^{-3}$)	Prediction ($\mu g\ m^{-3}$)	Prediction ($\mu g\ m^{-3}$)	Prediction ($\mu g\ m^{-3}$)
Flare 1	1051.5	591.3	831	616.9	550.6	541.8	541.4
Flare 2	369.6	210.8	238.9	217.3	208.9	198.5	182.8
Flare 3	254.4	143.33	188.7	178.1	178.1	162.1	161.9
Refinery Boiler	90.4	50.4	72.4	69.8	60.1	57.1	55.8
Compressor Engine	239.9	132.8	170.2	169.5	167	165.4	164.1
Parking Lot	177.4	176.5	130	128.4	124.1	123.6	123.5
Storage Tank	1	0.56	0.97	0.94	0.94	0.85	0.85
Plant #1	1051.5	591.3	831	616.9	557.6	552.7	548.5
Plant #2	965	535.6	706	613.3	548.6	547.8	538.9

Table 3-2B Maximum Predicted Hourly Average Ground-Level Concentrations - Lloydminster Meteorological Data (1988)

Source	ISCST3 Predicted Maximum (μg m^{-3})	0.55 σ_y Predicted Maximum (μg m^{-3})	High-2nd-High Prediction (μg m^{-3})	High-3rd-High Prediction (μg m^{-3})	High-4th-High Prediction (μg m^{-3})	High-5th-High Prediction (μg m^{-3})	High-6th-High Prediction (μg m^{-3})
Flare 1	926.3	513.7	744.5	550.4	550.2	550.2	549.2
Flare 2	313.7	179.5	264.8	260.1	196.5	186.5	184.5
Flare 3	265.6	149.2	199.9	185	185	184.9	178.3
Refinery Boiler	89.1	52.2	71.4	63.3	59.6	59.3	58.9
Compressor Engine	198.9	112	169.2	167.6	163.9	161.3	160.7
Parking Lot	185	183.8	166.2	150.1	117	116.6	110.8
Storage Tank	0.97	0.65	0.97	0.96	0.94	0.86	0.85
Plant #1	926.3	513.7	744.5	568	565.7	561.6	559
Plant #2	807.5	521	688.7	585.7	542.7	519.9	512.3

Table 3-2C Maximum Predicted Hourly Average Ground-Level Concentrations - Lloydminster Meteorological Data (1989)

Source	ISCST3 Predicted Maximum (μg m^{-3})	0.55 σ_y Predicted Maximum (μg m^{-3})	High-2nd-High Prediction (μg m^{-3})	High-3rd-High Prediction (μg m^{-3})	High-4th-High Prediction (μg m^{-3})	High-5th-High Prediction (μg m^{-3})	High-6th-High Prediction (μg m^{-3})
Flare 1	913.8	511.7	750.1	644.6	548.2	543.9	540.8
Flare 2	329.1	203.9	267	214.8	203.4	188.9	187.9
Flare 3	238.7	131.5	200.2	192.8	182.3	161.9	161.7
Refinery Boiler	109.2	61.2	91.8	75.4	68.1	63	61.7
Compressor Engine	215.9	125.4	168.4	163	162.6	157.9	155.5
Parking Lot	182.6	182.3	124.1	121.7	118.7	113.5	101.9
Storage Tank	1	0.56	0.96	0.94	0.85	0.75	0.67
Plant #1	913.8	511.7	750.1	644.6	556	555.1	547.1
Plant #2	1057.6	587.6	809.9	700.2	580.3	527.9	526.8

Table 3-2D Maximum Predicted Hourly Averaged Ground-Level Concentrations - Fort Saskatchewan Meteorological Data (1994)

Source	ISCST3 Predicted Maximum ($\mu g\ m^{-3}$)	0.55 σ_y Predicted Maximum ($\mu g\ m^{-3}$)	High-2nd-High Prediction ($\mu g\ m^{-3}$)	High-3rd-High Prediction ($\mu g\ m^{-3}$)	High-4th-High Prediction ($\mu g\ m^{-3}$)	High-5th-High Prediction ($\mu g\ m^{-3}$)	High-6th-High Prediction ($\mu g\ m^{-3}$)
Flare 1	975.3	543.8	801.2	745	671.7	624.2	541.9
Flare 2	338	197	265.6	250.8	234.1	230.8	227.2
Flare 3	207.5	114.1	205.3	204.6	194.9	184.5	184
Refinery Boiler	106.8	59.7	91.1	76.5	66.6	62.6	62.4
Compressor Engine	170.5	94.2	166.6	164.4	161.9	156.3	155.8
Parking Lot	187.5	185.3	181.3	180.6	178.3	168.8	163.8
Storage Tank	1.04	0.57	1.04	1.04	1.04	1.04	1.04
Plant #1	975.3	543.8	801.2	745	671.7	624.2	551.2
Plant #2	1095.4	616.4	869	805.4	751.5	742.5	688.1

First, it can be seen from the tables, that the area source is not affected by the different dispersion parameters. The concentrations are estimated by a double integral that minimises the effect of the dispersion parameters. Second, the compressor engine NOx results varies, but if an ozone limiting or NOx to NO2 relationship were applied, the difference between the two model predictions would be small. Thus the effect of using different dispersion parameters is minimised when modelling NOx.

Figure 1 shows the percentage difference between the HnH predicted concentration and the 0.55 highest concentration for the first through highest-sixth-highest values. To attain a reasonable comparison among the data, only the SO2 point source predictions are displayed as that is the main interest. Where a point is on the x-axis, the two models have the same prediction; a point above the x-axis represents an ISC3 prediction that is higher than the 0.55 model. Given the overall spread of the data, it is unlikely that any prediction from a HnH would be consistently close to the 0.55 model.

The figure also shows an example where differences between the HnH and the 0.55 predictions resulting from the continuous flare (Flare 3, Fort Saskatchewan meteorology) were frequently greater than the rest of the scenarios modelled. The meteorological conditions that gave rise to the maximum concentrations associated with Flare 3 were more frequent than the conditions that gave rise to maximum concentrations for the other scenarios. Also, the source is small in size and emissions which likely means that there is little buoyancy for dispersion under those meteorological conditions. This is an important factor to consider when modelling and designing a source.

Figure 2 shows a logarithmic trend line fit for each source. All of the trend lines except Flare 3 had a reasonable fit to the data. The trend lines show that the unadjusted ISC3 model's highest 5th (99.94 percentile) to 6th High (99.93 percentile) predicted concentrations were the best fit to the 0.55 adjusted model. However, many of the results were above these values, indicating that the 6th-8th highest might be a more appropriate match to the 0.55 version.

Figure 1 Percentage Difference between the 1st through 6th Highest hourly ISC3 maximums and the 0.55 adjusted ISC model

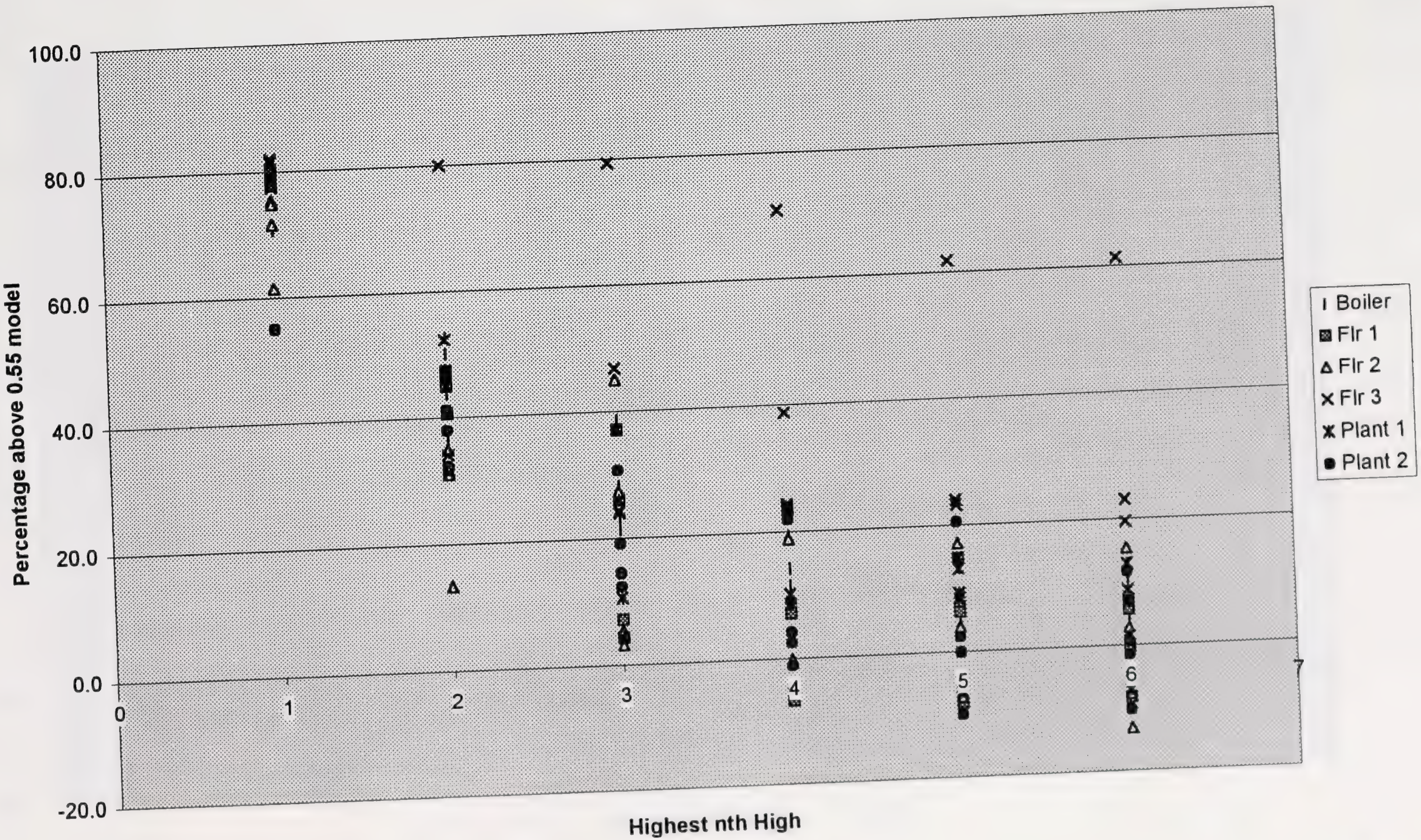
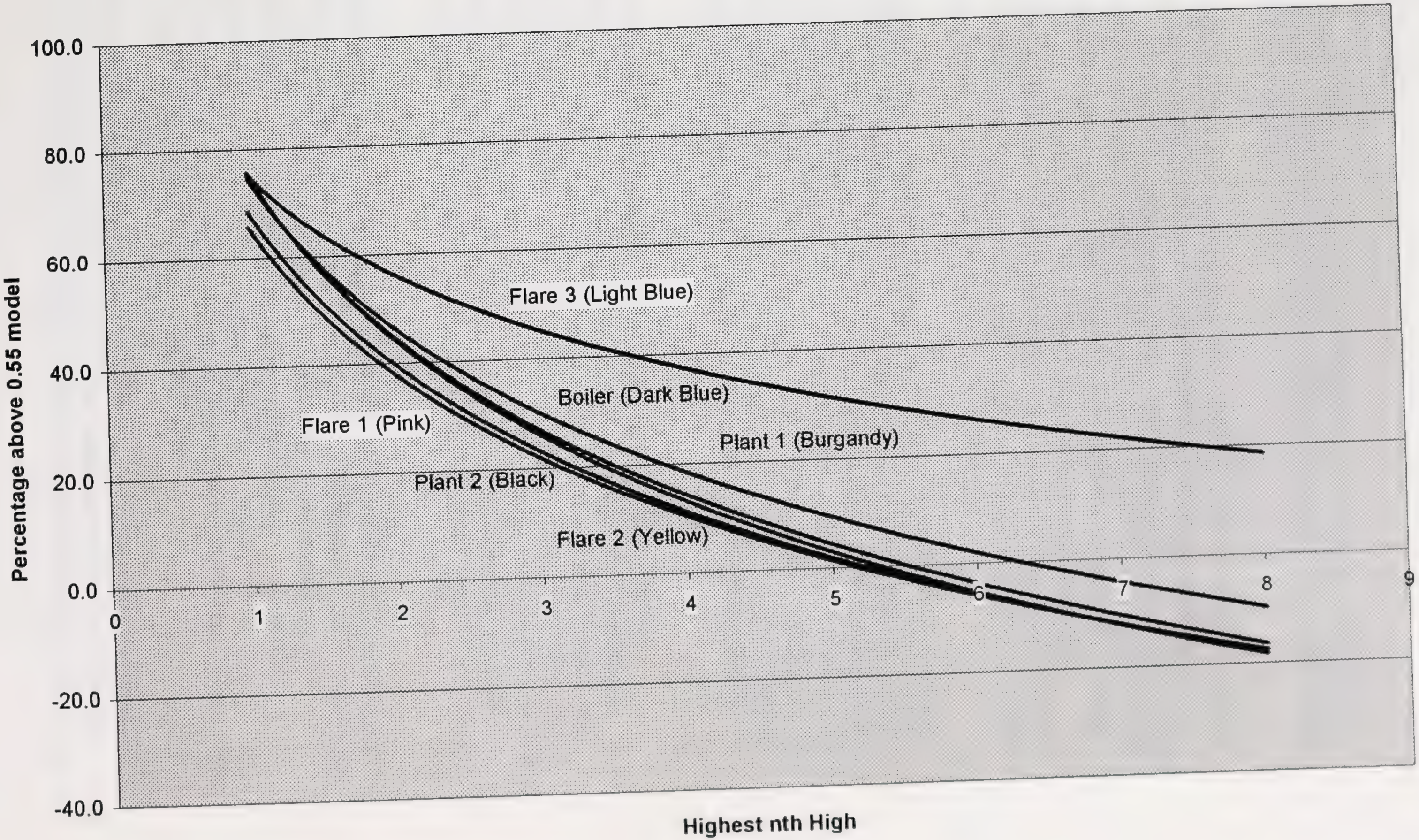


Figure 2 Trend of Highest 1-hour Point Source Concentrations utilizing different meteorological data sets



4.0 Discussion

The Model Change Working Group has investigated a number of ISC3 and SCREEN3 alternative modelling options to address the issues that were raised during the January workshop.

The ISC3 and SCREEN3 models, as they are currently used in Alberta, have a high degree of conservatism concerning the lateral dispersion parameters. These models use the P-G parameters as they were originally estimated, except they are applied for a 1-hour averaging time. This assumption is the equivalent of inferring that the wind is consistent for 20 3-min periods in one hour. Using these parameters in Alberta have resulted in ground level concentration predictions that are often much higher than any measured values. As a result, efforts have been directed towards the adjustment of these two models to better reflect what has been measured in the province in the past.

The first adjustment investigated was the "0.55 correction factor". The "0.55 correction factor" can be integrated into the ISC3 code, as application of the factor implies that the Pasquill dispersion coefficients need to be enlarged by a factor of 1.82 (1/0.55) in order to reflect wind direction variability. The correction only applies to point sources and flat terrain. The ISC3 model is readily applied, and this modular adjustment to the scientific basis is suitable, as the adjusted version would maintain the same sophistication level as the regular ISC3 version.

The second investigated alternative was the analysis of high nth high concentrations that can be predicted from the ISC3 model. This method is already in use by many of the regulatory agencies in the US and it does not require adjusted model code or continuous use of resources to maintain. It is a statistical analysis that can be applied directly in the model. The results from this method are somewhat consistent with modelling that has been performed previously in Alberta and it is also suitable in all types of terrain and for any type of source.

Concentration predictions in Gaussian models increase in the margin of error as one attempts to predict short-term worst case concentrations. This is due to the Gaussian equation base assumptions. The likelihood of predicting and subsequently monitoring the highest concentrations during a short-term averaging period is very small. By utilising a high nth high method, the confidence level of the assessment would increase, without having to recompile source code and offer support to an adjusted model.

Although there are advantages to the high nth high method, one drawback is that it can only be used by a time series model, such as ISC3. On the other hand, the SCREEN3 model was designed to model worst case conditions from a

single source only, and it has limited use. Therefore, the results from this model should be interpreted carefully. Any predicted exceedances of the ambient guidelines from SCREEN3 with out any adjustments warrant the use of a more refined model. The High nth High approach can then be utilised with ISC3 to determine whether predictions are above ambient guideline values.

5.0 Recommendations and Conclusions

The "Model Change Task Group" comprised of a voluntary group of consultants, industry, and the AEP has researched and addressed the "0.55 factor". This report described the background science behind the "0.55 factor", and investigated the use of the High nth High concentrations from the ISC3 model. After considering the integration of the "0.55 factor" into the model's code, the Task Group did not reach consensus. Instead, the group is supplying the following conclusions and recommendations for various solutions.

1. The "0.55 factor" can be implemented into the ISC3 and SCREEN3 models, with sufficient and ongoing resources. To ensure that the correction is implemented properly, a number of options are proposed to increase the confidence level of resulting predictions:
   - i) Step through the ISC3/SCREEN source code to make sure the correction is properly implemented
   - ii) A model performance evaluation should be completed

2. The "highest n^{th} highs" approach can provide more reasonable estimates than the regular ISC3 model and no redistribution or code adjustment is necessary. To ensure proper implementation of the high nth high approach:
   - i) No adjustment to source code is necessary
   - ii) A model performance evaluation should be completed

3. Based on the results of this paper, the 99.94 percentile concentration (5^{th} Highest) provides hourly concentrations on the conservative side of the 0.55 model, while the 6^{th} to 8^{th} Highest might represent closer predictions to the 0.55 model.

4. If Recommendation 2 is selected, the Highest 6^{th} - 8^{th} High hourly value should be used to demonstrate the worst case concentrations for regulatory requirements. This would be an interim value based on the modelling to date.

5. A "watchful eye" should be placed on newer models such as AERMOD and CALPUFF to determine whether they are more suitable for regulatory requirements.

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Appendix A

Summary of Follow-up Meeting on Alberta Environmental Protection's Draft Air Quality Model Guidelines

April 30th, 1998,9:00am - 12:00pm

As a result of the Workshop on Alberta Environmental Protection's Draft Air Quality Model Guidelines, a task group to look at the "0.55" factor and its applicability to the ISC3 model was formed. A meeting was held on April 30th 1998 to discuss modifications to the U.S. EPA models. The objectives of the meeting were to determine the validity or appropriateness of using the correction factor, how it should be implemented if it is appropriate, and to discuss other options if it is deemed inappropriate. The following is a brief synopsis of what took place at the meeting.

The meeting was held by the AEP and was chaired by David Slubik. The following people were in attendance at the meeting.

David Slubik, AEP
Alex Schutte, AEP
Doris Weiss, Tartan Engineering
Douglas Leahey, Jacques Whitford
Rod Sikora, Gulf Canada Resources Ltd.
Brian Zelt, Golder Associates (now with E2 Environmental Alliance)

The meeting was called to order, and David Slubik made introductory statements and detailed topics to be discussed including: 1) Detail terms of reference for this group, 2) Its membership, 3) Timeline for completion, 4) Resources for tasks.

At the start of the meeting, questions were raised regarding the background of the models that are currently being used. Interest was expressed to describe the differences and similarities between the U.S. EPA models (ISC3 and SCREEN3) and the SEEC model.

David gave a brief history of the two models, and described how the SEEC used the 0.55 correction factor and the ISC and SCREEN do not. Further discussion ensued on what the proper way to apply the correction factor is, and everyone agreed that applying the correction factor after running ISC or SCREEN is not correct, and the correction must be included within the source code of the models themselves.

Doug Leahey suggested that the 0.55 correction factor does have scientific basis and should be applied to the ISC model. This idea was discussed around

the table, and on a "technical" basis, everyone agreed that there was a scientific basis for the correction, however, it may not be "practical" to implement the correction. Alex and David suggested that the 0.55 correction is not the only option and other "solutions" which may be less costly to implement could be looked at.

Doug suggested that the use of the Briggs dispersion coefficient could be a possible option to use in the ISC model. Alex and David suggested that the Highest Second High concentration from the ISC model might also be an option.

Doug brought some model results of the 0.55 corrected model compared with ambient monitoring data. Cumulative frequency charts were presented which showed that with the correction factor, there was a pretty good correlation with observed data. Rod noted that the results seemed reasonable considering the complexity. However, Doris and David noted that the model under-predicted in some cases. Brian explained that this was a result of using "average" conditions in the model where as the observed cases were probably "upset" conditions and would not be accounted for in the modelling, therefore the results remain reasonable. It was pointed out that in order to do a proper comparison, actual concurrent emissions, meteorological, and monitoring data would need to be used. Also, we must keep in mind that the purpose of the model changes are still for regulatory purposes, and not to match observations or solving problem events.

Rod volunteered some data that he has previously archived which may be of some use to compare the correction's effect on terrain features. He pointed out that if the 0.55 correction is not going to be used, there will be many implications as to the Grandfathering aspect, and would there be an answer to that?

Alex presented some modelling results which compared the default ISC3 model, ISC3 using the High Second High (HSH) option, and ISC3 with the 0.55 adjustment. The results showed some inconsistencies in the 0.55 version, which may indicate that the model may be harder to correct in the source code. The results also showed that the HSH concentrations were much closer to the corrected version numbers.

Everyone expressed interest in the modelling results, and requested a copy of the results, as well as the modelling computer files. Doug Leahey agreed to let his re-compiled 0.55 version available to everyone, and AEP promised to email the results and the model version.

Doug noted that the HSH seemed to be an interesting option, everyone at the table somewhat agreed. Brian added that he likes the "scientific" approach of the 0.55 correction, rather than applying a "band-aid" solution such has HSH. Rod noted that the HSH answer is no better as a technical answer because it does

not account for the frequency of the meteorological event being more or less common than the high answer; and no doubt the reason HSH is discussed is that it is acceptable in some jurisdictions.

David commented that the HSH is being used in the US, and is widely accepted. He also noted that the 0.55 correction is not the only correction that may be needed in the ISC model if one were to take the "scientific" approach. There are other factors, such as vertical dispersion, which are also not correctly incorporated into the model.

A discussion regarding the status of the SEEC model had the following results:
If the ISC model is not adjusted, the SEEC model should be abandoned. It would be unfair/inappropriate to have one model using 0.55 while the other one does not.
There was no support for the SEEC model, and the model should be abandoned completely.

Rod submitted that the '24 hour concentration', either as a 24hr limit or converted to the 1hr limit, when using the 1hr worst case/ license conditions seems equally as acceptable and perhaps easier to explain than following a method such as the EPA just because "that is the way they did it".

Some other points that were brought up during the meeting that are worth mention:

1. There is a possibility that more refined/detailed complex models be used as an alternative to get a more technically correct answer. (This is only good for some cases.)
2. Whatever recommendation is made can not be made in isolation of the effect that it is going to have on existing facilities.
3. Q. How much taller 'typically (flat & complex terrain)' will a new stack have to be using ISC as is?

David then outlined some tasks that would be taken.

The model results would be distributed for everyone's review and comment. If anyone had other results they would like to add, they would be appreciated.
A "task group" draft report will be prepared that will include:

> A background and summary of what the 0.55 correction factor is, what High Second High is, how they are used, and what the implications are.
> It will outline the pros/cons of the options discussed.
> Abandonment options of the SEEC model
> Justification of an option
> Opportunity for Comment

Grandfathering implications and actions will be discussed soon, and will probably require a larger group. Everyone was thanked for coming to the meeting and donating their time and effort, and the meeting was adjourned.

APPENDIX B
Summary of 2nd Meeting - Model Modification Task Group
September 24th 1998, 10:00am to 3:00pm

In Attendance:

Michael Brown, Alberta Energy Utilities Board
Douglas Leahey, Jacques Whitford
Martin Rawlings, Golder Associates Ltd.
Alex Schutte, AEP
David Slubik, AEP
Rod Sikora, Gulf Canada Resources Ltd.
Brian Zelt, E2 Environmental Alliance

Agenda:

1. Approval and addition of items to agenda
2. Review of Previous Meeting minutes
3. Outline of Meeting Objectives
4. Detailed Review of Report and Discussion
5. Grandfathering
6. Stack Design
7. Discussion
8. Next Steps to be Taken

Summary:

1. Approval and addition of items to agenda:

David Slubik opened the meeting at 10:10am.
Rod brought to everyone's attention that this is a very important issue to CAPP.
There were no new specific items to add to the agenda that could not be addressed in discussion.
The agenda was approved and the meeting commenced.

2. Review of Previous Meeting minutes:

David Slubik gave a brief outline of the last meeting of the group and asked if everyone is satisfied with the minutes. (Currently Appendix A of DRAFT Dispersion Modelling Adjustments Report)
Everyone accepted the minutes and was satisfied.

3. Outline of Meeting Objectives:

David Slubik outlined that the main objective of the meeting was to come to a decision about the 0.55 factor and the high second high model options, discuss other suitable solutions, and attain consensus among the group. If consensus with in the group is not possible, the opinions of everyone in the group will be gathered and included as comments in a final report. Ultimately, the report will be a public document, so it is important to have each person's opinion represented.

No one objected to this possibility.

4. Detailed Review of Report and Discussion:

Alex Schutte presented a brief review of the report that discussed the background, the options, the modelling that has been completed to date, and the draft recommendations of the report.

Everyone confirmed that they understood the options that were presented in the paper however, there were many differing opinions on the draft recommendations. The following main points were discussed:

i. The 0.55 factor - Strengths and Shortcomings in the ISC model
ii. High Second High - Strengths and Shortcomings
iii. Use of Alternatives - 0.55
HSH
Interpretation/Probability Approach
99.9%/High nth High
Longer Avg to 1-hour
iv. Defining the Approaches
v. Code Changes vs. External Changes
vi. Verification and Justification of Model Changes
vii. Alternative Models
viii. Resources with in the government

A summary of each point is provided below:

i. The 0.55 factor has been used in Alberta for quite sometime and there is a good scientific basis for its use. To utilise the correction properly, a source code change is required in the ISC3 model. This correction is not the only correction that could be incorporated into the EPA models.
ii. The High Second High is used in the USA and will account for the conservatism in the model. It is consistent with how the models are

utilised in the rest of North America. It does not require a source code change.

iii. Some alternatives were discussed. In order to speed up the process of attaining consensus, everyone was asked to choose two options, out of the five listed above, that they would prefer. The results were:

0.55 ---3, HSH---1, Inter/Prob---4, 99.9%/HnH---5,Lng Avg---1

iv. The "interpretation/probability" approach would be to not modify the model at all, interpret the raw model results as they are and determine the probability at which high concentrations occur. However, there was confusion over the actual definition of this, and it was felt that the approach was too broad and should either be defined better or not be considered. The 99.9%/High nth High is an approach that was used in Alberta in previous guidelines, and is similar to the High Second High but with different maximum levels. This was the most popular option. The "Longer Avg" approach would take a predicted 24-hour concentration and have it converted to a one hour to compare with 1-hour guidelines. With little support, this option was abandoned. The HSH approach was also abandoned, however the 99.x%/HnH is similar to HSH.

v. Code Changes versus No Code Changes was discussed. Everyone's opinion on making code changes to the model was given. The room was generally split on the issue.

vi. The verification and justification of one of these options was discussed. AEP put forth that a change in the model source code would have to go through a verification process. Although the HnH is not a change to the model code, it was felt that if verification is done for the 0.55, than it should be done for the HnH. It most likely should be done for any modification that will be implemented in the guidelines.

vii. It was noted that the 0.55 factor issue exists due to the use of the ISC3/SCREEN3 models. If alternative models are utilised, the 0.55 factor is not an issue. Therefore, another option that could be implemented would be to discontinue the use of ISC3 and adopt the "more accurate" models.

viii. The resources that are required for each of these options were discussed. It was decided that some more modelling needed to be done before an option is selected. AEP deems that implementing a source code change will require much more long-term resources than the other options. Others feel that the alternative options presented will require the same amount of resources. It was noted that all of these options only apply to the ISC model. The new models that are coming out are based on different science. If these new models are incorporated in the guidelines, none of these current changes would be long term in nature.

5. Grandfathering

Dave Slubik stated that Grandfathering issues are deemed to be a separate issue and beyond the scope of this group. It is recognised that the outcome of what this group decides will have implications on grandfathering, and therefore it will be likely that AEP will have a policy on grandfathering in place around the same time that the final guidelines are released.

6. Stack Design

Rod Sikora presented a brief discussion on model usage for stack design. Two cases, design of a sulphur incinerator and design of an acid gas flare stack were presented using different available models to predict worst case concentrations. The Stacks2, Screen3, and ISCST3 models were run to predict the one hour worst case concentration at a given stack height. Then, stack heights were adjusted in each model until the Ambient Guideline concentrations were met.

The results generally showed that there are a number of different ways in which the models can be utilised to design stacks and that more work may be necessary to come up with the most suitable method should the 0.55 option not be utilised.

7. Discussion

See Section 4 for Discussion

8. Next Steps to be Taken

i. A summary of the meeting will be composed and distributed among the group for discussion and edits
ii. Modelling will be performed that will compare the 0.55 model to a High nth High and 99.x%. Where the models are closest to being equivalent will be determined, to gain perspective on the differences. From this, a suitable "level" may be determined.
iii. Rod will review his stack design results, and make it available once it is complete.
iv. Comments and opinions from individuals in the group should be submitted in writing to AEP so they can be included in the final report.
v. The next date for a meeting has not been set. An effort will be made to try and accomplish as much as possible via email and writing prior to setting another meeting date. A final meeting may be necessary once the modelling is complete.

The meeting finished at approximately 3:00pm.

Appendix C

Consider the Gaussian equation for ground level centerline and crosswind concentration.

$$C = \frac{Q}{u\sigma_y\sigma_z\pi} e^{-y^2/2\sigma_y^2} e^{-H_e^2/2\sigma_z^2} \qquad (1)$$

Where C = concentration of emissions, g/m^3 at any receptor located: x meters downwind
y meters crosswind from the plume centreline
Q = source emission rate, g/sec
u = horizontal wind velocity, m/sec
H_e = plume centreline height above ground, m
σ_z = vertical standard deviation of the pollutant distribution, m
σ_y = horizontal standard deviation of the pollutant distribution, m

If the concentration calculation is made two different ways, one where σ_y = p (ISC3 model) and the other where σ_y = 0.55p (peak-to-mean adjustment), and everything else remains constant; The two equations would be:

$$C_1 = \frac{K}{p} e^{-y^2/2p^2} *(k) \qquad (2)$$

$$C_2 = \frac{K}{0.55p} e^{-y^2/2(0.55p)^2} *(k) \qquad (3)$$

Where K and k are both constants.

The ratio of (2) and (3) is

$$\frac{C_1}{C_2} = \frac{0.55e^{-y^2/2p^2}}{e^{-y^2/1.1p^2}} \qquad (4)$$

From equation (4), the following can be deduced. If the point of interest is on the plume centerline (y = 0), the exponent parts of the equation become 0 and the adjusted maximum concentration would be 0.55 of the unadjusted equation. If however, y is greater or less than 0, as one moves away from the plume centerline, the adjusted predicted concentrations become closer to the ISC3 model until a critical distance, when the adjusted predictions will be greater than the ISC3 predictions. See Figure 3 for an illustration of the predictions as a function of crosswind distance. The units in the figure are dimensionless.

Figure 3 Predicted Concentration as a function of crosswind distance from the plume centreline for the ISC3 and Adjusted Models